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Beria, Paolo and Lunkar, Vardhman

Politecnico di Milano

5 June 2020

Online at <https://mpra.ub.uni-muenchen.de/100896/>  
MPRA Paper No. 100896, posted 10 Jun 2020 07:44 UTC

# Presence and mobility of the population during Covid-19 outbreak and lockdown in Italy

## WORKING PAPER

Paolo Beria<sup>1\*</sup>, Vardhman Lunkar<sup>1</sup>

<sup>1</sup>*Dipartimento di Architettura e Studi Urbani, Politecnico di Milano*

*\* corresponding author: Paolo Beria (paolo.beria@polimi.it)*

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### Abstract

The non-medical policies implemented to “flatten the curve” and to reduce the stress on the health system during the COVID-19 outbreak represents a critical event in the history of Italy. This kind of “lockdown” has left people stranded in their homes and, for some, out of their homes unable to return to their region of residence due to the disruptions in the mobility network. As a consequence, a vast scale of research is being performed to understand the patterns of mobility of people during the emergency. The availability of rich datasets has made it possible to quantify the dynamics of spatial distribution of people as a response to the strict measures. With the help of the data provided by the Facebook – Data for Good program, an effort is made to describe and to reason on the presence and of mobility patterns of the population at a regional and provincial scale during the lockdown. Our interpretation is that, initially, tourists left the country and later Italians abroad managed to return from abroad stabilising the population. Concerning internal mobility, it is evident that the earliest affected Regions see a higher number of stationary users in the initial days of the outbreak. On the other hand, the central and the southern regions does not display a positive relative change of staying home until the official lockdown is announced on the 9<sup>th</sup> of March, 2020. Before the stricter lockdown started there was not a significant exodus of people from the North to the rest of the country. To the contrary, a visible relocation of people occurred between the cities and their urban belts.

keywords: covid-19; outbreak; lockdown; mobility; Facebook data for good; location based mobility, big data; social network; Italy

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### 1. Introduction

The outbreak of COVID-19 has resulted in a health crisis on an unprecedented global scale. It has induced stress on the national health systems and has consequently led to extreme measures from the respective governments to contain the virus. The “lockdown” measures adopted to mitigate the spreading coverage of the virus in Italy has frozen almost every social and economic aspect of the nation. Thus, it is of paramount importance to estimate how the patterns of mobility have been altered during the emergency. Several researchers are now using data provided by social networks to assess the situation and monitor the short- and long-term effect of this disaster. This paper is an application of the *Facebook disaster prevention maps* (a part of the *Facebook – Data for Good* programme), which is a collection of method for processing Facebook data into dynamic spatial-temporal maps that illustrates how populations are preparing for, impacted by, and coping with a crisis situation. The maps utilise anonymized and aggregated data, with focus on current and historic location sensing, information on cell connectivity accompanied with privacy and security maintenance by adding random noise and filtering out small values, are shared with humanitarian organizations in the days

and weeks following a crisis. Comparing the public response to the interventions in terms of the rate of mobility on a spatial-temporal scale, measured relative to the baseline (pre-crisis conditions), can unarguably provide an insight into the effectiveness of emergency interventions. Consequently, it will help attain better efficiency in case of a resurgence of emergency situations. Thus, an effort is being made to analyse this aggregated data and deduce the presence and movements of people during this period.

The paper starts, in Section 2, with the literature available on mobility disruptions during such crisis situations. Section 3 gives a brief description of the datasets adopted by us by defining the metrics used for performing the analysis. Section 4 introduces the COVID-19 outbreak in Italy and the timeline of the salient events that took place afterwards.

Three principal research questions have been addressed in the remainder of the paper. The first one (Section 5) is how much and to what extent people “stayed at home” before, during and at the opening of the lockdown. Despite the media narration of people ignoring the lockdown, data clearly show that since March (the lockdown was declared on March 11<sup>th</sup>) the share of people moving and the range of movement fell dramatically to a nearly physiological level (supplies, health workers, necessary trips).

The second one (Section 6) is if there was an “exodus” of population during the weekend between the announcement of the national lockdown and its actual start. In particular, if a significant movement of people can be observed between the North and the rest of the Country.

The third one (Section 7) is about the relocation of people’s residence during lockdown. In particular we are interested to verify if cities have emptied and where population has moved: far away, in the periphery, towards second houses at the sea or countryside or abroad (tourists or expats/migrants and the corresponding return of Italians from abroad).

## 2. Studying real time mobility during crises

In the nearly two years since Disaster Maps launched, the datasets have been used during major disasters in nearly every region of the world. During the Thomas, Carr, Mendocino Complex, and Camp wildfires in the USA, the non-profit organisation Direct Relief used the maps to monitor how populations affected were moving and then used this to guide distribution of hundreds of thousands of respiratory masks, as well as to coordinate with networks of health centres to alert hospitals that might see increased volumes (Snibbe, 2018). In August of 2018, Kerala, India experienced severe flooding that displaced over a million people. SEEDS India used the Facebook Population and Displacement maps to appropriately time and calibrate their works on relief, recovery, and rehabilitation operations. After identifying when people appeared to begin to return home, SEEDS (Sustainable Environment and Ecological Development Society) launched a nationwide collection drive for widely needed items (Gupta, 2018). The Facebook population change maps were used to understand the patterns of displaced population and identified hot and cold spots of population change during the California fires (Shenyue Jia, 2020).

More recently, during COVID-19 outbreak, the use of Facebook data has reached a broader extent, with scholars and institutions working nearly real-time on numerous aspects of the outbreak and of the lockdown. In their ongoing research combined the *Movement data* from Facebook and the economic data from official statistics to understand the economic downturn of mobility restriction arising from the lockdown in Italy, the first European country affected (Bonaccorsi et al., 2020). It was demonstrated that the impact of the lockdown depends on the country’s internal mobility structure (Galeazzi et al., 2020). They compared Italy, France and Italy and found that the mobility network after the lockdown was more concentrated for UK and France but distributed in the case of Italy. In exploring how variation in mobility relate to some fundamental economic variables, it is found that reduction in connectivity tends to be stronger for high-income inequality municipalities. The first quantitative assessment of the impact of measures on the mobility and the spatial proximity of Italians, was done through the aggregated data provided by Cuebiq (Pepe et al. , 2020). They

estimate a reduction of 50% of the total trips between Italian provinces, following the lockdown. In the same week, the average users' radius of gyration has declined by about 50% and the average degree of the users' proximity network has dropped by 47% at national level.

Out of Italy, the changes in mobility of United States through different proxy signals using the mobility data also provided by CUBEIQ (Brennan Klein et al, 2020). They quantified the reduction in mobility at the macro, meso- and microscopic level to examine the degree of social distancing and to answer questions on the trajectory of the pandemic. Kissler, 2020 used the aggregated movements map and associated reductions in mobility in and out of the New York boroughs with the prevalence of the SARS-CoV-2 infection. Denis et al., 2020 have used the Facebook Movement data to clearly show that lockdown was effective in reducing overall mobility in India and to further realise that cities lost between 4% and 11% of their population, while rural population increased by 7%. In addition to this, some long-distance mobility was observed during the first week of the implementation of the lockdown. Facebook mobility and movement range data was used to understand the impact of the social distancing policy measures on the spread of the SARS-CoV-2 virus in the greater Seattle Area (Burststein, 2020). The impact of human mobility and travel restrictions on the potential spread of COVID-19 in Taiwan was modelled (Chang et al, 2020). They compared the impact of intra-city vs. intercity travel restrictions on both the total number of infections and the speed of outbreak spread and developed an interactive application that allows users to vary inputs and assumptions. They found that intra-city travel reductions have a higher impact on overall infection numbers than intercity travel reductions, while intercity travel reductions can narrow the scope of the outbreak and help target resources.

This research is an addition to this list, providing a better understanding of local and intercity mobility patterns during the outbreak in one of the most hit countries. It is also a step towards validating that *Facebook disaster maps*, coupled with other tools, can be an effective way of comprehending crisis ground realities and could be of potential help to decision-makers in managing them.

### 3. The datasets

The programme *Facebook Data for Good* made available numerous datasets, also called *Facebook Disaster datasets*, for entire countries and/or for single regions/cities (described in Maas et al., 2019). In the case of Italy, the data is available at the country-scale ("Italy Coronavirus Disease Prevention Map package"), with some more detailed focuses on single cities. For this paper we focus on country-scale data. We will use three of the available datasets:

- a. the Movement Range;
- b. the Movement between administrative regions – NUTS-3 provinces, in the case of Italy;
- c. the Facebook Population (Tile Level).

All datasets used contain spatial and temporal information based on the behaviour of Facebook users with active GPS and active Location History (in the case of Italy, approximately 5-6% of the population) with up-to-date information. The data is detected passively and is fully anonymised without individual information of the users. Individual information is aggregated spatially (either using tiles or administrative borders) and temporally (every eight hours: 00:00AM, 8:00AM and 4:00 PM, corresponding in Italy to 02:00 AM  $\pm$ 4h, 10:00 AM  $\pm$ 4h, 06:00 PM  $\pm$ 4h and perfectly fitting with night, morning and afternoon).

The datasets have the potential to replicate a picture of crisis situations with a certain level of detail and global coverage. However, such type of Location based Social Network data has its limitations and caveats. The Facebook population is not fully representative of all demographic and socio-economic groups within a population. This is valid to municipalities having low Facebook penetration. Due to usage habits, old people are typically underrepresented in such data. Since such kind of data requires the user to keep their location services on and not everyone allows Facebook to

access their location, a further population bias is introduced which can lead to skewed results relative to what is happening in reality. In addition, the baseline information refers to 45 (movement) or 90 (presence) days prior to the event and the period could not be a “real” baseline when describing long events. For example, the outbreak started during Winter but deployed during Spring; consequently, any crisis vs. baseline comparison is biased also of the seasonal change.

In the following, all these unavoidable biases will be considered when describing the mobility-related patterns observed during the outbreak. As a counterpart, these datasets provide a unique material to study nearly-real-time events, at a global scale and based on a huge population base.

### 3.1 Movement Range

In order to quantify the effect of lockdown to pre-crisis level, *Movement Range trends* datasets are available. There are two types of metrics that are elaborated in this section.

- a. Travel Range: This explains the average number of level 16 Bing tiles (0.6km x 0.6km) that a Facebook user (with location services on) was present during a 24-hour period relative to the pre-crisis levels. Thus, it can be used to measure the degree of change of mobility range.
- b. Staying Put map: This metric explains the percentage of Facebook users (with location services on) that stay on one such tile at 3 different hours of the day. Thus, a stationary user is analogous to staying put or staying home.

### 3.2 Movement between administrative regions

The *Movement between administrative regions* aggregates dynamic movements of users in terms of geographical coordinates. It takes into account who moved from a given cell to another between the time periods. The data is then aggregated at Italian provincial level (corresponding to NUTS-3). Such maps provide insights into understanding movement patterns, whereby response organisations can predict where resources are needed, evacuation patterns or even predict congestion spots. The metrics that are provided by this dataset include:

- a. Baseline: This indicates the total number of users moving from their origin to their destination calculated as an average over the 45 days prior to the beginning of the crisis.
- b. Crisis: This indicates the total number of users moving from origin to destination during the specified time-period. A measurement is taken into consideration (and the entry is present in the dataset) only if this value is greater than the threshold (10 movements), otherwise it is discarded. This introduces an underestimation of flows especially between sparse or very far destinations.
- c. Difference: This indicates the difference (in percentage) between the number of people moving from origin to destination during crisis with respect to the baseline.
- d. Standard (Z) Score: The number of deviations by which the count of people moving during the crisis differs from the number of people moving anytime during the baseline.

### 3.3 Facebook population (tiles)

The *Facebook population (tile level)* provides the number of active Facebook users spatialised in a tile matrix. We use the national scale dataset, where the tile size is approx. 4800 metres of edge and aggregate basic tiles. The data provided is the number of geo-localized Facebook users every 8 hours present in the tile during the crisis and in the corresponding day/hour of the baseline.

The metrics that are provided by this dataset include:

- a. Baseline: This indicates the average number of Facebook users present in the location during the last 90 days prior to the event (in this case 24<sup>th</sup> of February 2020). The baseline value is segmented by the day of the week and the time window for the metric, to be comparable.
- b. Crisis: This indicates the average number of Facebook users present in the location during the crisis.
- c. Difference - The difference between the population at the time of the crisis and the population during the baseline.



#### 4. The COVID-19 outbreak in Italy

Italy was the first European and Western country where the 2020 COVID-19 outbreak developed locally. The first confirmed cases were separately found in Codogno area (south of Milan) and in Veneto near Padua, both on February 21<sup>st</sup>. Two cases were already found in Rome on January 31<sup>st</sup>, but they were Chinese tourists that contracted the virus in China. Other cases probably spread in Europe even before the Italian ones, but they were not recognised or were isolated.

On February 22<sup>nd</sup> Italian government established a local lockdown in 11 municipalities (10 in Lombardy and one in Veneto). On March 4<sup>th</sup> all schools and universities in the country were closed. In Northern Italy mobility already dropped since the 24<sup>th</sup> of February, with companies starting moving to smart-working and people avoiding public transport.

The country-scale lockdown, the first in Europe, started on March 11<sup>th</sup>: all working places, except essential ones, were closed and people was requested to stay home except for food purchasing. The lockdown was anticipated on March 7<sup>th</sup>, when a draft of the decree circulated, talking about a possible closure of most of Northern Italy since 9<sup>th</sup>, but this measure was overpassed few days later by the full lockdown started. However, according to media, many people left the cities of Northern Italy towards the South. Those who remained in their location cannot move anymore until the end of the measure (not even among neighbouring municipalities and theoretically also within). At that moment of lockdown, Italy had about 12.000 official cases and more than 800 deaths. This first phase of lockdown lasted until May 5<sup>th</sup>, when a progressive relaxing of closures started, including industry and most of retail. To date, movements between regions remain not allowed, but this is due to end, at least for some, on June 3<sup>rd</sup> 2020.

The pandemic in Italy hit most Northern Italy, and Lombardy in particular. The outbreak spread from four locations: Codogno, Vò (Padua), Bergamo and Pesaro. In short other provinces are included among the most hit, namely Milan and Brescia. Apart population and effectiveness of the response, which both play a role, Central and Southern Italy were less hit because the lockdown started before a significant number of cases occurred, while in the North lockdown was definitely late, when diffusion was enormous. This put some regions among the ones with in the highest per-capita rates in the World.

#### 5. The decline of local mobility

Exploring the relation between the *Movement Range* metrics on a scatter plot from the period 21<sup>st</sup> February 2020 to 30<sup>th</sup> April 2020 it seems clear and logical that the more stationary a region is, the lesser the travel range. We notice in Figure 1 how the restrictions and the populations adherence to the lockdown intensifies temporally in the month of March and April. Though, this figure is principally to demonstrate the evident correlation between the two metrics, Figure 2 shows a more disaggregate temporal variation of the *travel range* metric for the respective macro-regions. We observe how the implementation of early restrictions reduces the North-West (Lombardy being epicentre region) and the North-East (Veneto being the second outbreak region) relative to the other macro-regions. The *travel range* has drastically reduced during weekends and we can note the sharp decline in the mobility behaviour after the official announcement of the lockdown on the 9<sup>th</sup> of March, 2020 after which the behaviour of all regions become analogous and convergent to each other. On the same graph we can also observe the *Share of people staying home* metric, which is nearly a mirror of the former, but with less macro-regional differences.

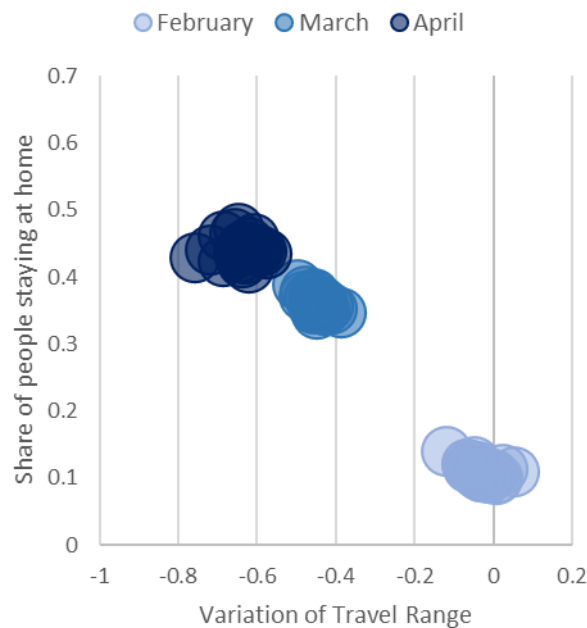


Figure 1 Correlation between variation in Travel Range and share of people Staying home – regional averages.

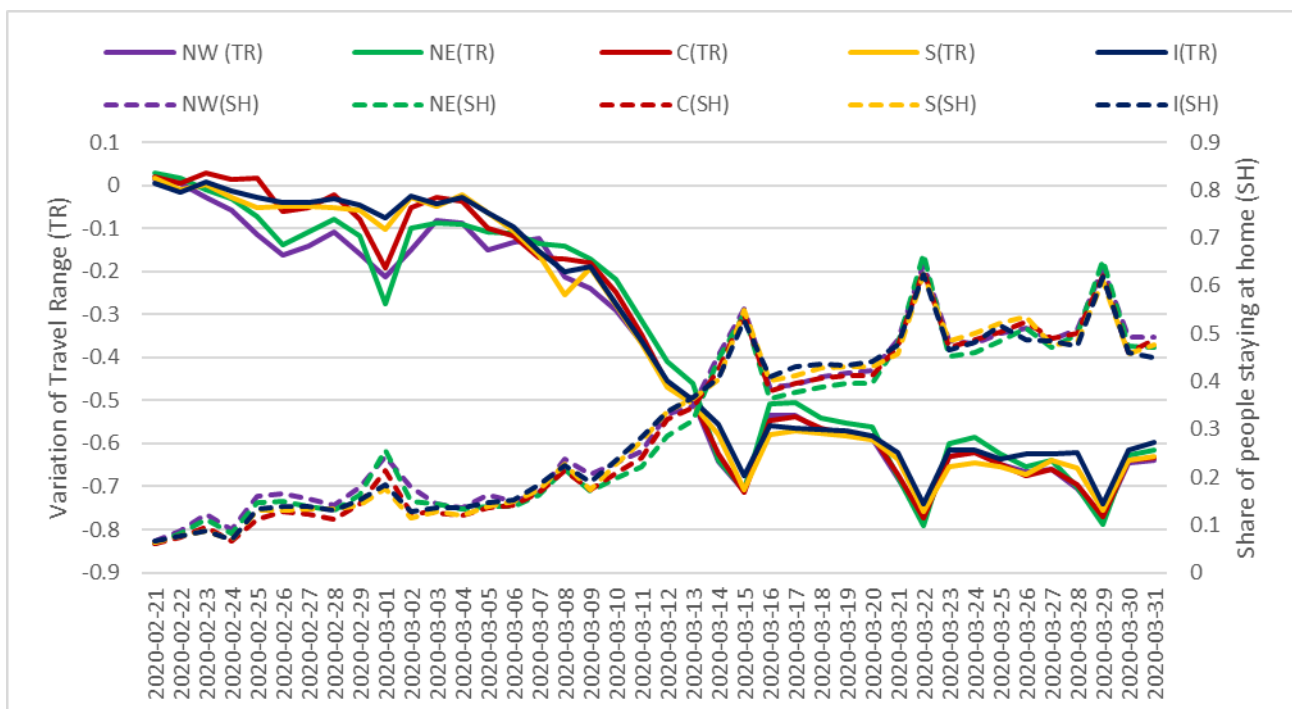


Figure 2 Relative number of total tiles for macro-regions (Travel Range)

Further, the relative change with respect to the national average for three significant days (24<sup>th</sup> February, the start of the dataset, 9<sup>th</sup> March, the start of national lockdown, and 24<sup>th</sup> March, 2020, the lowest point in presence, see Figure 8) in particular are elaborated above in Figure 3. It is evident that the earliest affected Regions see a higher number of stationary users in the initial days of the outbreak. Lombardy which is the epicentral region of the outbreak experiences a 37% higher than national average of users staying put at home followed by neighbouring regions of Liguria (23%), Emilia Romagna (15%), Friuli-Venezia-Giulia (14%), Piemonte (12%) and Veneto (9%). The regions

of Aosta valley and Trentino Alto Adige which are popular ski destinations observe movements which might be due to tourists leaving the region. On the other hand, the central and the southern regions does not display a positive relative change of staying home until the official lockdown is announced on the 9<sup>th</sup> of March, 2020. This progressive reduction of the movements and more of percentage of people confining themselves in their homes after the official announcement is validated further in Figure 6. While the overall percentage of people staying at home on a national scale rises towards the end of March, the relative change in the Central and Southern regions becomes relatively higher than that of North-East and North West Italy.

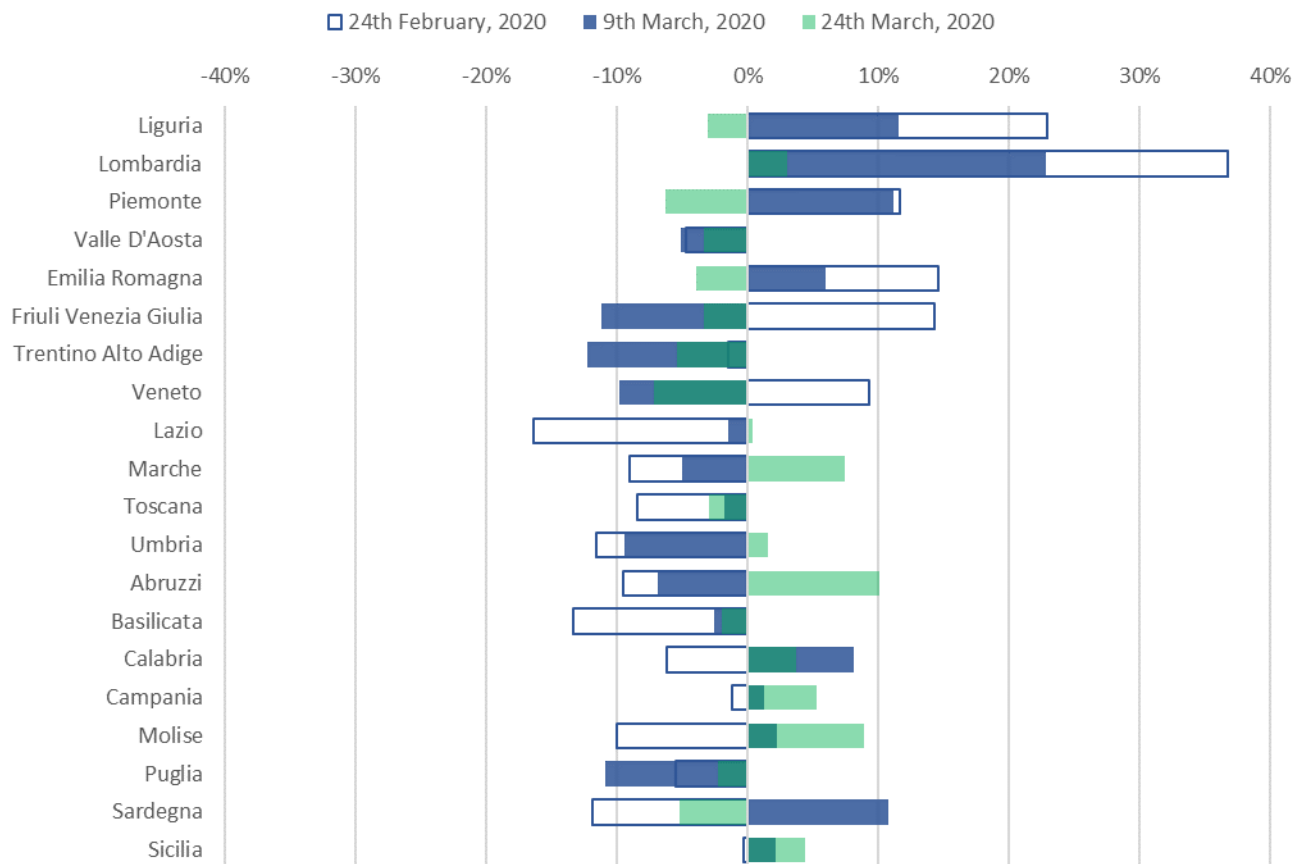


Figure 3 "Staying Home" relative change with respect to national average for regions

## 6. The start of lockdown: the tale of an exodus (that did not happen)

The spread of the outbreak, but especially the national lockdown started on March 9th, has pushed part of the population to relocate before getting "locked" into their current position. A recent research, applied in the totally different context of India (Denis et al, 2020), has shown quite clearly a dynamic of "escape" from cities towards the rural areas. More precisely, rural population increased by 7% while cities lost between 4% and 11% (from metropolis to small census towns). This effect is attributed both to the decrease of everyday/weekly commuting, but also – locally – to a consistent movement of migrant workers towards locations whose lower density was considered as safer. This is the case of flows from Delhi to Northern India, and of Rajasthan, Odisha, Bangalore and Chennai towards smaller localities of origins of migrants.

In the case of Italy, media has given a lot of evidence to a sort of "exodus" occurred especially in the night of 8-9 March 2020, when the last night train from Milano to the South had been "assaulted" by people that feared to remain locked in the northern capital. This tale has shaped significantly the debate on media and social media, assuming that the exodus has happened and the spread of



potentially infected people from the North to the South would have caused further outbreaks and collapsed the health system.

The *Movement between Administrative Regions* dataset – that in Italy correspond to NUTS-3 Provinces – allows to verify if and to what extent such displacement happened. We have considered the entire period available, starting from February 24<sup>th</sup> to the mid of May, after lockdown was relieved. Figure 4 considers all movements between Italian provinces (i.e. excludes internal trips). During the first two weeks of the outbreak – before the lockdown was declared – the decrease with respect to baseline was negligible (90%). Only weekends' trips were well below the expected, showing that the behaviour was modified first for personal trips rather than for work trips. During the 1<sup>st</sup> week of lockdown, the mobility fell suddenly and reached level of 30%/20% of normal. Weekend trips basically disappeared until May. Interestingly, starting from end of March ratio crisis/baseline increases more during night time than daytime: it means that people is still not going to work, but is restarting to go out for leisure.

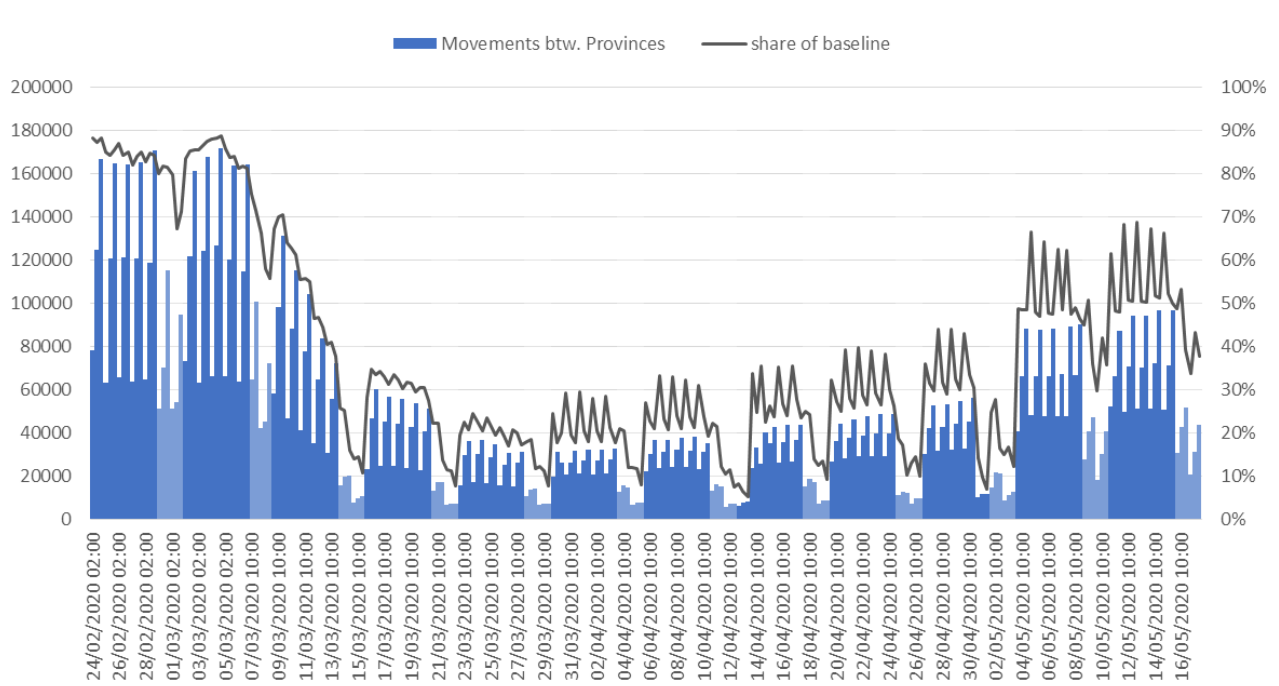


Figure 4. Total movements between provinces (NUTS-3) and share of baseline.

Regional differences are interesting too (Figure 5). As expected, in the North interprovincial trips were already below the normal level since the beginning (also confirmed in Figure 3), when in the South the difference with baseline is negligible. In the Centre some reduction was already present during the first weekend of March. The macro-regional series start matching since March 9<sup>th</sup>, when Central and Southern regions are even slightly below the North-East. Later we see only some daily fluctuations, with the exception of North-West – where the risk was higher, and the lockdown perceived as more severe. At the end of March, trips begin to rise again, ranging from 20% to 40% of baseline almost everywhere, including North-West. In the North-East, where the outbreak, despite severe, was very well controlled since the beginning, trips restarted earlier than the national average.

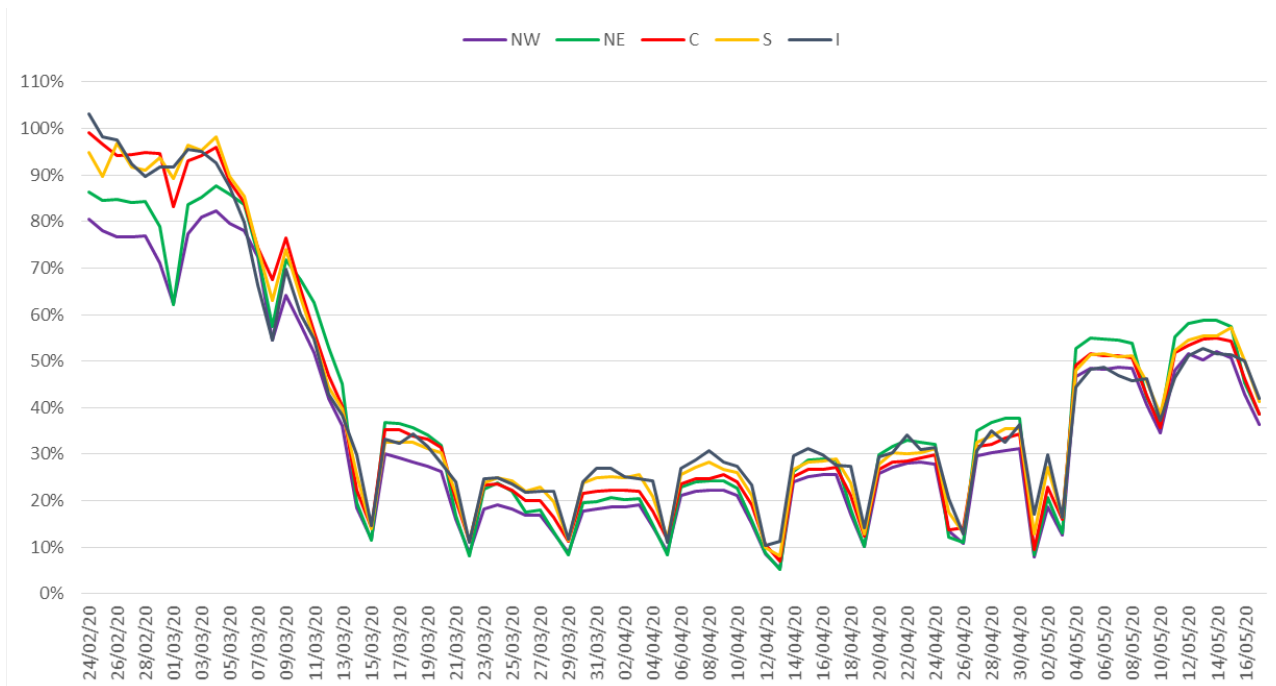


Figure 5. Total movements between provinces (NUTS-3) grouped by macro-regions. Share of baseline.

Mapping these flows shows again the progressive end of movements across the country, which in the 2<sup>nd</sup> half of March looks disconnected (Figure 6). While initially we can recognize the usual patterns, with most of the flows within the North and along the coasts, plus some long-distance ones for example connecting Milan with Sicily, Already on March 9<sup>th</sup> they were substantially reduced. On March 24<sup>th</sup> the connections are basically absent, with the exception of some local trips among neighbouring provinces. Some connections between Rome and Sardinia and Sicily remain, probably connected with cargo movements.

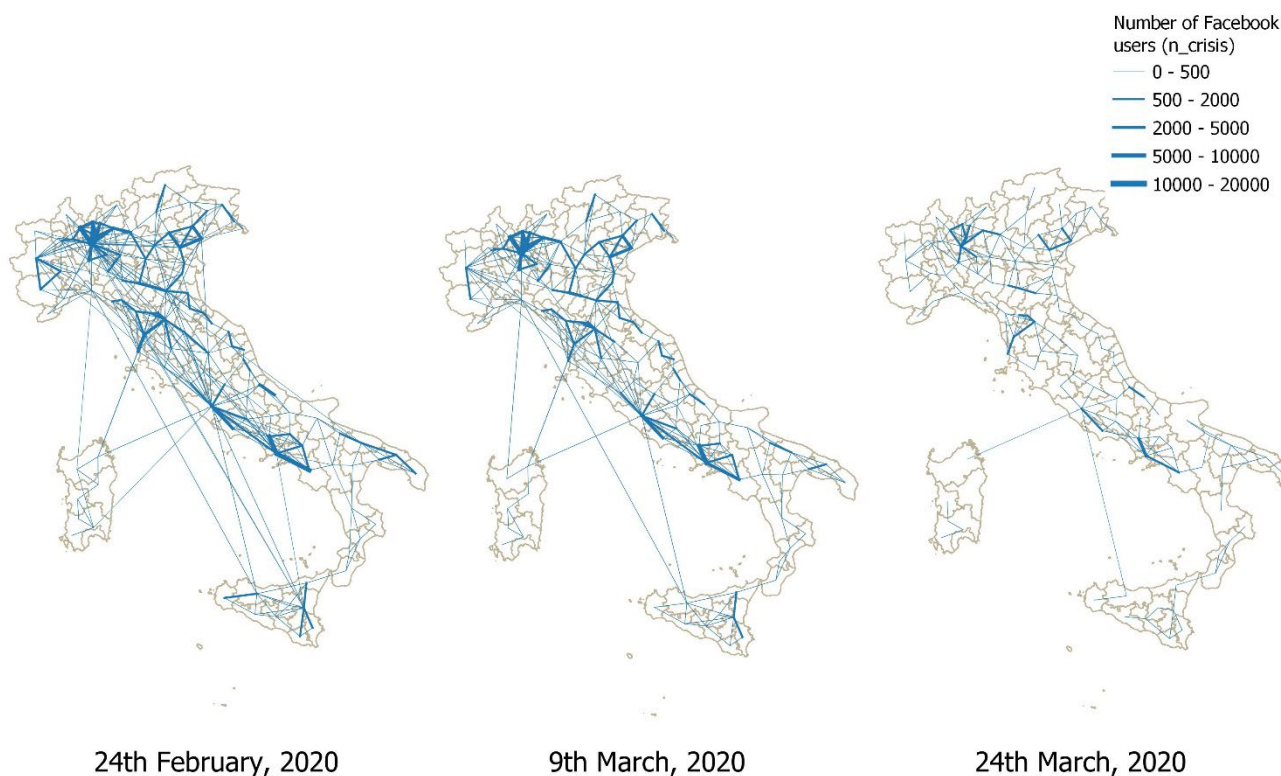


Figure 6. Interprovincial flows before and during lockdown.

By means of these observations, we can also verify if there were anomalous trips between the North and the Centre and South, especially at the moment of declaration of lockdown, as perceived by public opinion. Figure 7, for example, plots the outgoing trips from the entire Lombardia<sup>1</sup> to the rest of the country. Not all destination regions are represented since there no OD pairs with more than 10 trips (which is the threshold of the original data). Emilia Romagna and Piedmont account for the largest flows, which is natural being at the same time large and neighbouring. Typically, during weekends these flows fall, as leisure connections are more limited than working ones. To the contrary, in direction of Liguria, Val d'Aosta and Trentino Alto Adige – despite on a different scale – we see some increase during weekend, in particular starting Friday 6<sup>th</sup> March and the following Saturday. The highest point of these flows is around 250 users, which should correspond to approx. 5000 people, per day per region. Therefore, in conclusion, we can affirm that, even from Lombardia no significant pour of population from North to South or elsewhere can be observed, or is in the order of thousands of people.

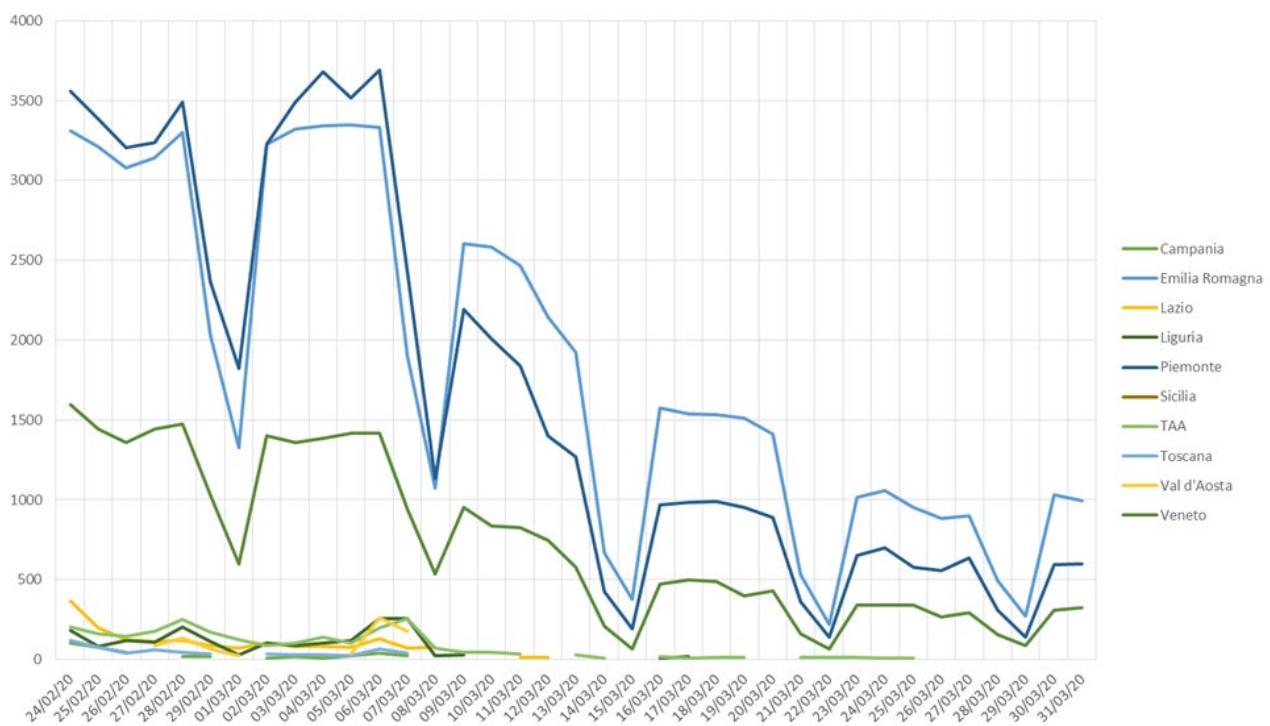


Figure 7. Total interprovincial movements from Lombardia to the rest of the country (internal trips in Lombardia excluded).

## 7. Away from cities, away from contagion

After showing that no significant exodus occurred, it is more interesting to verify if cities have emptied and where population has moved: far away, in the periphery, towards second houses at the sea or countryside or abroad (tourists or expats/migrants and the corresponding return of Italians from abroad).

In this case we use the *tile-level Facebook population data*. At the national scale tiles measure approx. 4800 metres of edge and aggregate more basic tiles. The users present during crisis are compared with the baseline calculated on the presences during the 90 days prior to the event (in this case 24<sup>th</sup> of February 2020). As already underlined before, also this data is not statistically representative and cannot be properly expanded to the entire Italian population, but is very meaningful to show trends and to describe the behaviour of the large subset of population. Overall, the dataset

<sup>1</sup> Lombardia is the largest region (10M inhabitants), the most hit and the one from where media described the exodus. Figures from other regions were even less significant.

includes about 3,3 to 3,4 Million people, corresponding to about 6% of Italian population (but including also non-Italians temporarily present in the country).

We aim at responding to two basic questions:

- 1) Can we observe a significant regional relocation, in particular between North (where the outbreak started) and the Centre/South, not catch by *Movement* dataset?
- 2) Or is there a relocation between dense cities and low-density areas, meaning either countryside, remote areas or simply second houses areas and seaside?

To do that, we work at the tile level to produce difference maps and then we attribute every tile to the corresponding region (NUTS-2 level) and to the official classification of core and remote areas in use in Italy (called SNAI: Barca et al., 2014)<sup>2</sup>. We work using the nighttime slot (10PM to 6AM), to avoid measuring the effect of commuting.

The first relevant result is related to totals. Differently from India – where total population was constant (Denis et al., 2020) – in Italy during the analysed period we observe Figure 8 a sharp decline in population starting from March 10<sup>th</sup> (after the 1<sup>st</sup> day of lockdown). Facebook users pass from 3.370.161 individuals (almost equal to baseline) of March 10<sup>th</sup> to 3.241.722 of March 10<sup>th</sup> (-4%). In 3-4 weeks, this figure rises again. Our interpretation is that initially foreigners and especially tourists left the country (we will go back on this later on), and later Italians abroad succeeded to re-enter<sup>3</sup>. The figures of the 28 April are the most interesting as represent a sort of picture freezing the position of Italians during lockdown and can also be used as a reference to calibrate the sample matching it with census data (typically biased by commuting and temporary touristic presences).

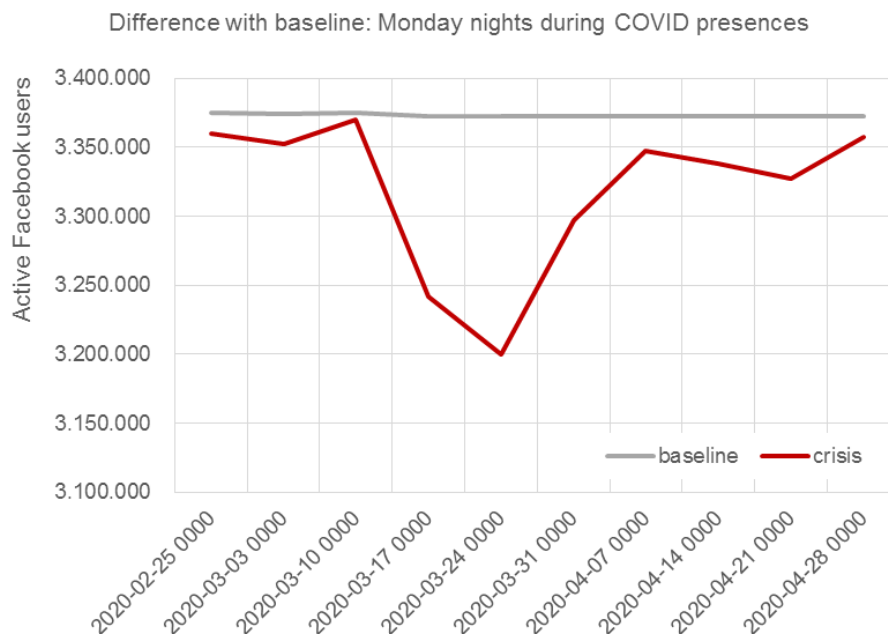


Figure 8. Total population observed during nighttime (10:00 PM of Monday to 6:00 AM of Tuesday), referred to baseline.

To respond to the first question, if there was a significant relocation between regions (invisible in the Movement figures of Section because spread across many OD pairs below the threshold), we attribute the population tiles to regions, as in Figure 9. It is related to the most stable observation, namely the night of 27-28 April. With few exceptions, population of regions is basically constant. Only Valle d'Aosta and Trentino Alto Adige lose a significant share of population (around 10%).

<sup>2</sup> The six classes are: Hub, Inter--municipal, Outlying, Intermediate, Peripheral and Ultra-peripheral. The classification is a service-based accessibility indicator, based on three variables: time to access high-schools, hospitals and main train stations.

<sup>3</sup> it must be remembered that during lockdown airlines and train stopped operations and returns were managed by the Ministry of Foreign Affairs.

This figure can be easily explained noticing that they are small mountain regions where the previous weeks were the full winter ski season.

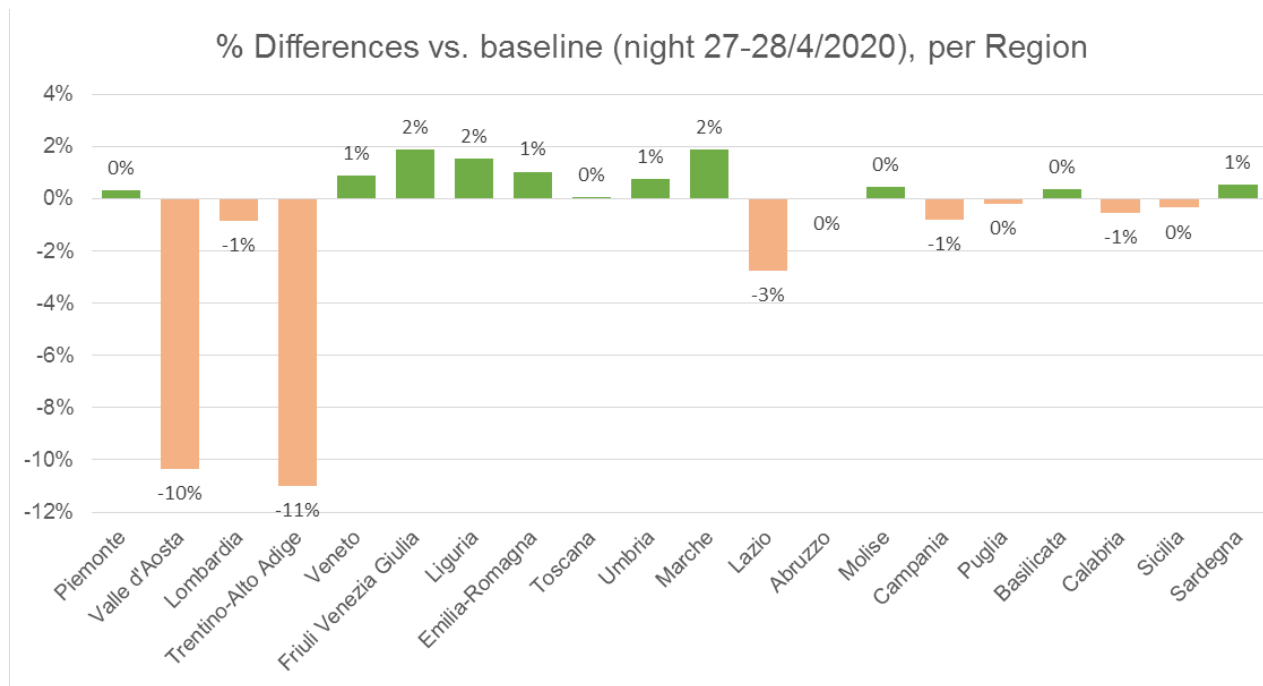


Figure 9. Percentage difference between crisis and baseline observation, by region. Night between 27 and 28 April 2020.

Figure 10 gives the absolute numbers. Lombardia and Lazio (the regions of Milano and Rome, respectively) lose 5-10.000 Facebook users (which should correspond to approximately to 80-160.000 persons). Another 5.000 leave Trentino-Alto Adige, most likely Italian and foreign tourists. Remaining regions show variations between 0 and 3.000 users, with. Central ones (Liguria to Abruzzo) gain population and Southern regions (Molise to Sardegna) lose some. Regional

differences, overall, say that we cannot observe significant displacements, especially from North to South, except the sudden end of the ski season in the Alps.

Differences vs. baseline (night 27-28/4/2020), per Region and area

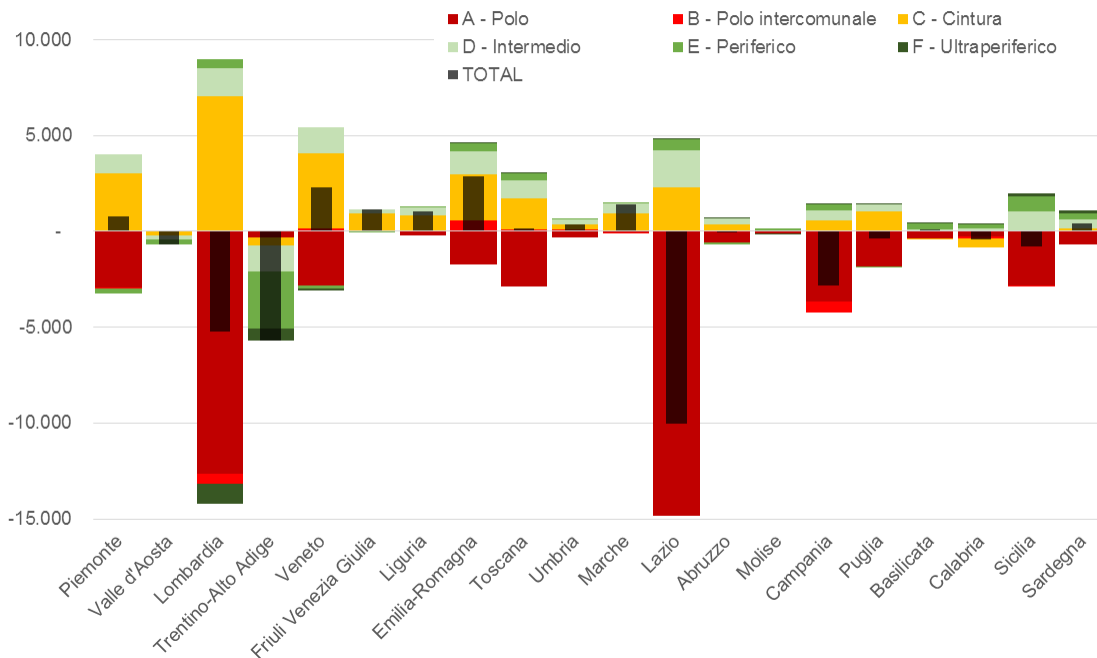


Figure 10. Difference between crisis and baseline observation, by region and by SNAI classes. Night between 27 and 28 April 2020.

Figure 10 is helpful also to respond to the second question, if there was a relocation from cities to “outside”, whatever this means. Following maps will be more detailed in this, but the national classification of remoteness is already meaningful (Barca et al., 2014). Again, with the exception of the two small Alpine regions where remote areas that get empty are ski resorts, the pattern is a clear escape from cities, in particular the “poles” or “hubs” (usually provincial capitals and surroundings that lose 4,1% of their population), in the direction of *Intermediate* territories (that gain 1,8% of population), that could be described as the mid-density non-urban areas. The three peripheral classes (D to F) gain population, but in the order of few thousands overall.

This pattern means that the loss of population of cities must be attributed to the escape of tourists and the lack of weekly commuters<sup>4</sup> that now stay at home often within the region, but limitedly to the movement of people towards remote areas.

<sup>4</sup> daily commuters should be excluded because the time slot is 10PM to 6AM, when normally commuting is still very limited.



The map of Figure 11 represents the first week of the outbreak (night between 24 and 25 February 2020). It clearly shows that there is a fall in population only in some cities in the North. Naples and Palermo, in the South, should not be attributed to the outbreak but to seasonal movements. Urban areas of Emilia Romagna, Tuscany and central Italy – whose climate is similar to the North – do not show any decline in presences. Rome and Florence are more crowded than before, sign of the start of the city-focused spring touristic season.

Monday night between  
24 and 25 February 2020

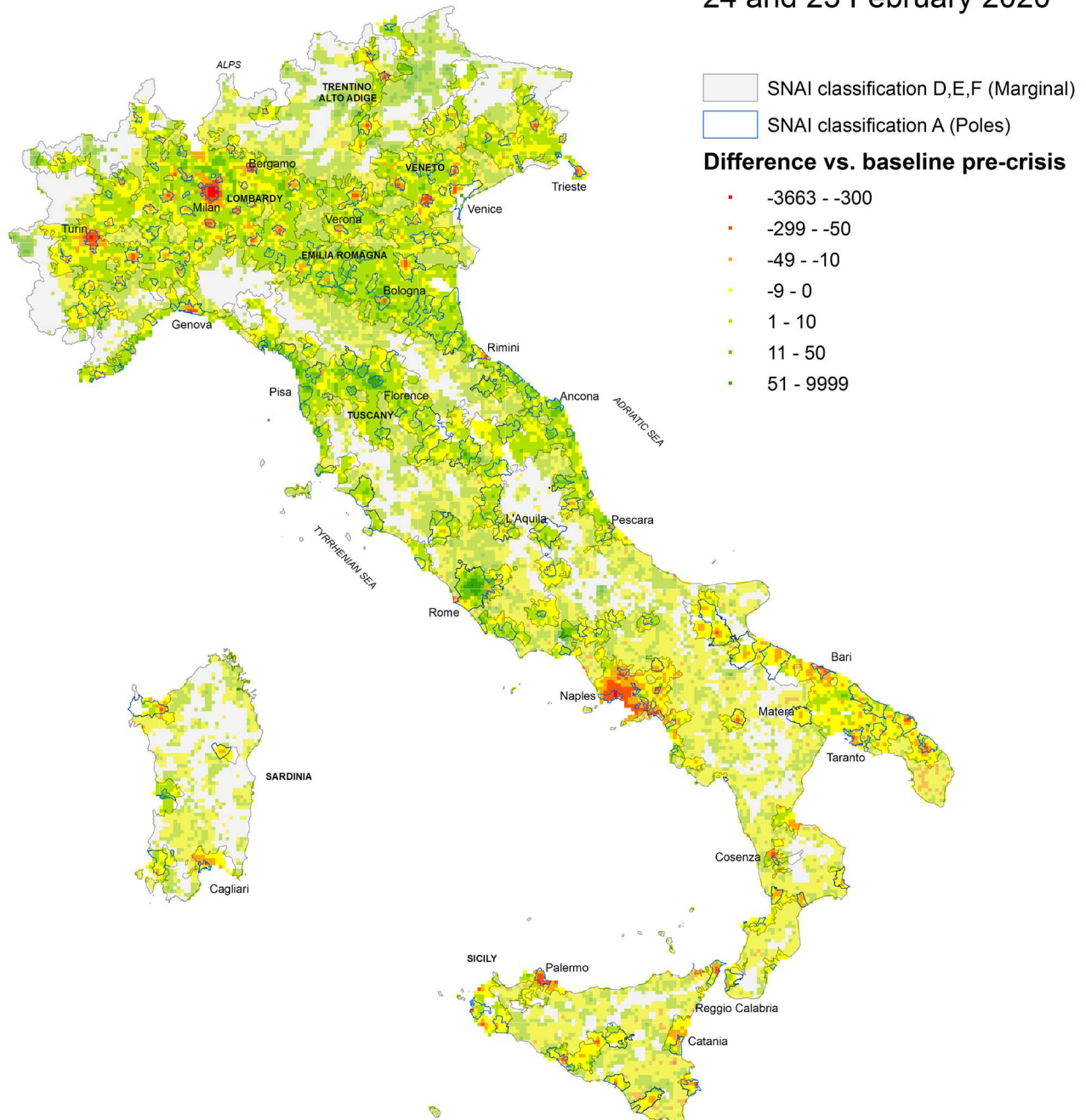


Figure 11. Population difference vs. baseline. Night between 24 and 25 February 2020 (first week of outbreak).

During the peak of outbreak at the end of March (Figure 12), the fall of population is the largest in *all* parts of the country. All “poles” got emptier but almost nowhere population significantly increased, including remote areas. Again, this shows that there was not a pouring of population from one to another (very few “green” tiles), but a net loss, particularly pronounced in cities. It is interesting to notice the dramatic decrease of presences in Trentino-Alto Adige and Lombard valleys, from where all ski tourists departed.

Monday night between  
23 and 24 March 2020

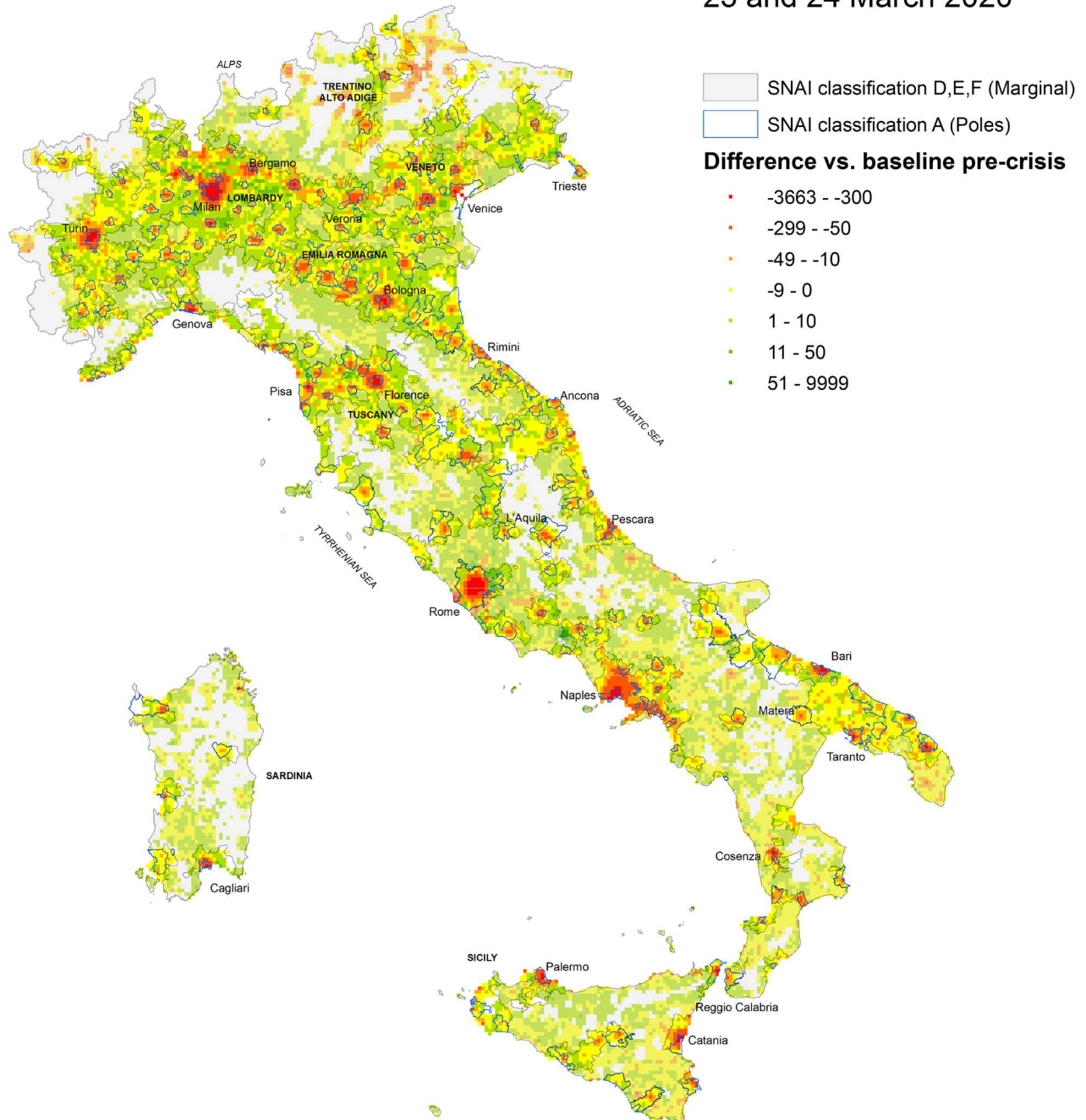


Figure 12. Population difference vs. baseline. Night between 23 and 24 March 2020 (outbreak peak).

Finally, the most stable day is the night of 27-28 April 2020, shown in Figure 13. Most of Italians abroad returned and most likely occupied their place of origin. Cities are totally blocked – no economic activities – with their resident population locked in. Here we can appreciate that, with few exceptions, the largest population increase are in urban belts (around Milan, between the cities of Veneto, along the Adriatic coast, between Florence and Pisa, around Rome, Naples and Bari. In other words, the most inhabited part of Italian territory out of cities.

Monday night between  
27 and 28 April 2020

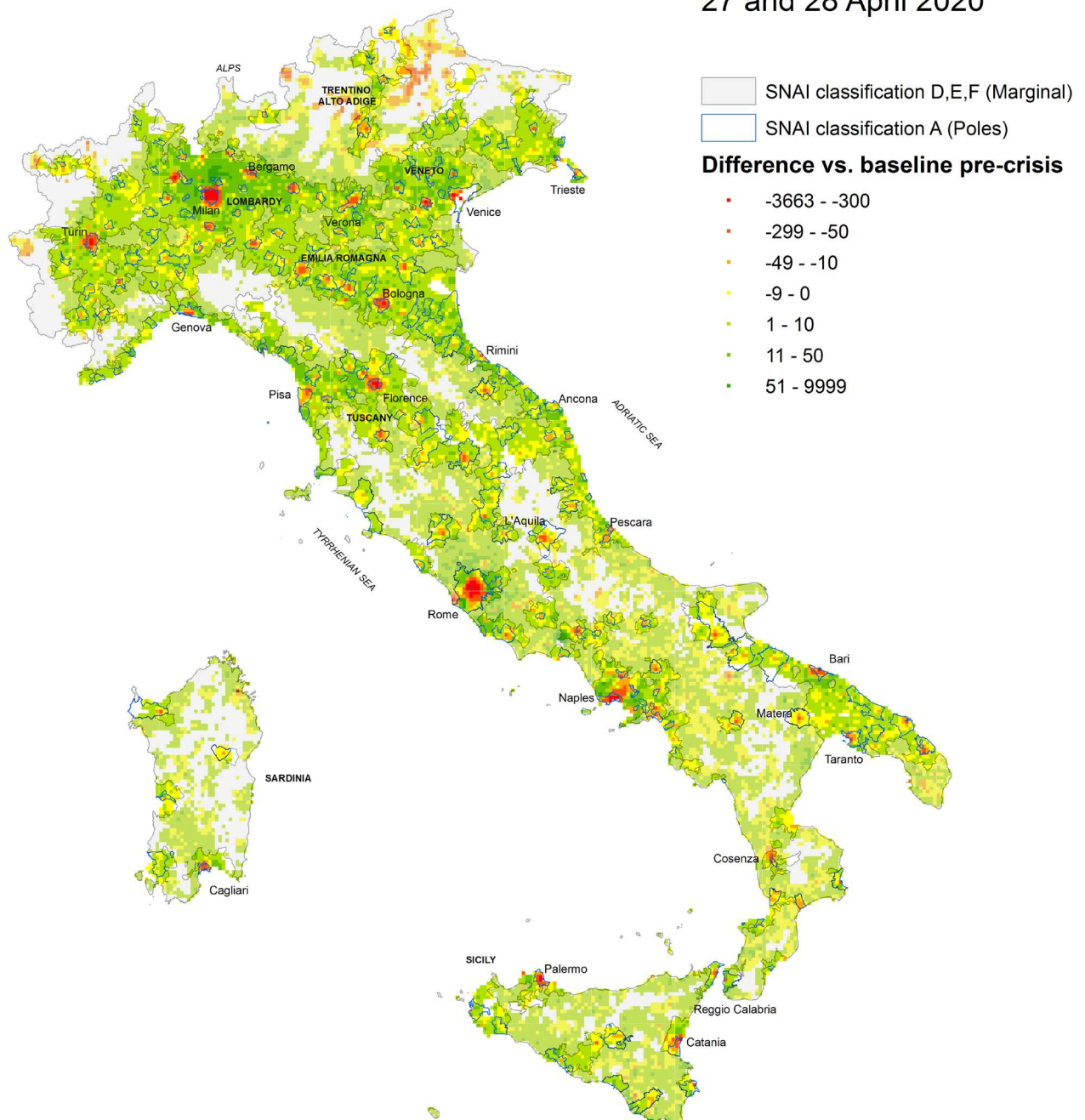


Figure 13. Population difference vs. baseline. Night between 27 and 28 April 2020.



There are some exceptions and they often belong to the areas – not all, however – where second-houses concentrate. For example, as mapped in Figure 14 filtering tiles with an increase of more than 20 Facebook users, some well-known touristic sites appear, such as Ligurian coast between Genova and Santa Margherita; the Versilia area and part of Tuscan coast; the “litorale romano” (the beaches south of Rome); Ischia, Costiera Amalfitana and Lago Patria near Naples. The remaining tiles all belong to urban belts.<sup>5</sup>

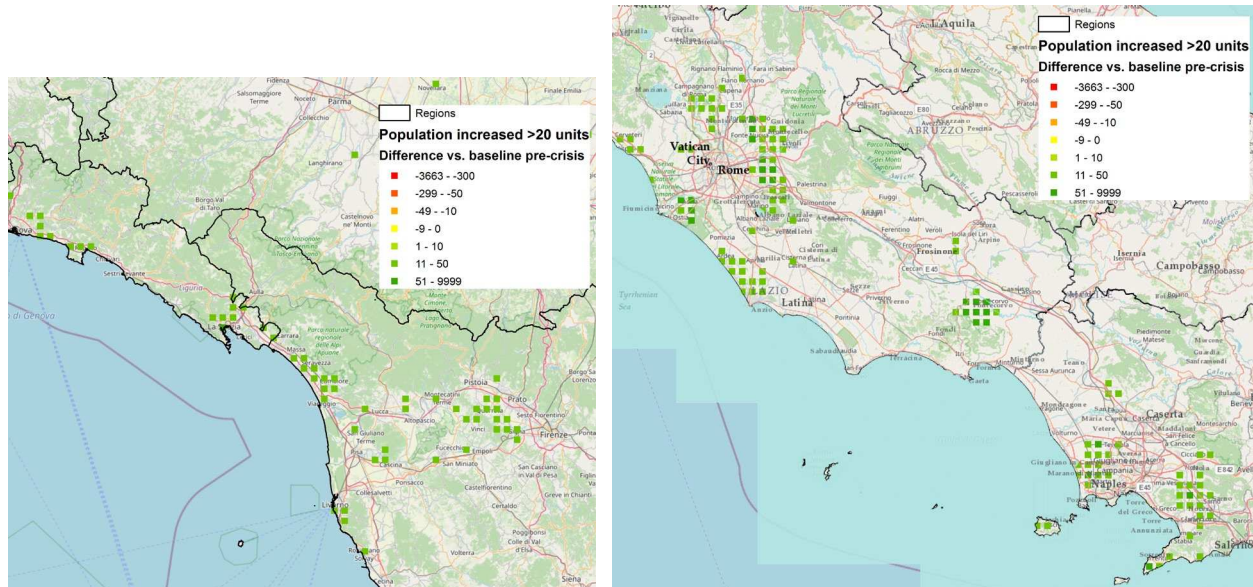


Figure 14 Population difference vs. baseline higher than +20 users. Night between 27 and 28 April 2020. Detail of the Levante Figure and of Tuscan coast (left) and of the area between Rome and Naples (right). Background map: Openstreetmap.

## 8. Conclusions

The COVID-19 outbreak had (and will have) enormous consequences in the mobility of entire countries, including country-scale lockdowns. Italy was the first-hit country in Europe and among the ones where it resulted more severe. In this paper we provide an in-depth analysis of mobility during COVID-19 outbreak and lockdown in Italy using the data provided by Facebook Data for Good programme. These dataset are used to trace almost real-time the movements and the presence of people during disaster and disease events.

In this work we mainly tried to answer to three research questions. The first one is how much and to what extent people “stayed at home” before, during and at the opening of the lockdown. Despite the media narration of people ignoring the lockdown, data clearly show since March (the lockdown was declared on March 11<sup>th</sup>) the share of people moving and the range of movement fell dramatically to a nearly physiological level (supplies, health workers, necessary trips).

The second point was about the movement of population just before the lockdown, especially from the northern provinces, the most hit, and central and southern Italy. This movement happened very marginally, with few thousands of people crossing the country to avoid remaining locked. Some non-local trips remained, but they are substantially confined to neighbouring provinces. Long-distance trips remain nearly always below the measurement thresholds.

The last aspect deals with the location of people during lockdown. The most visible phenomenon is the fall of population in largest cities, starting from the North but soon happened also elsewhere. People did not relocate (except few, of course) in marginal areas, but basically concentrated in the rest of urbanised areas. This fact has a twofold explanation: commuters and city users stopped moving into urban poles and out-of-home workers went back to the place of origin, which is often inside the region.

<sup>5</sup> The area of Cassino, well visible, should be an effect of the baseline as documented by data developers.

In conclusion, the Facebook data resulted extremely useful to provide a picture of *real* mobility and location behaviour of people, allowing to go beyond the perception and possibly to correctly support public decisions.

### Acknowledgements

The paper is based on the datasets made available by Facebook through the Facebook Data for Good programme <https://dataforgood.fb.com/>.

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